ALASKAN AIR COMMAND
ARCTIC AEROMEDICAL LABORATORY
FORT WAINWRIGHT

A NEW HEAVY WINTER FLYING CLOTHING ASSEMBLY

by James H. Veghte and
James I. Clogston

TECHNICAL NOTE
AAL-TN-61-14

SEPTEMBER 1961

A NEW HEAVY WINTER FLYING CLOTHING ASSEMBLY

James H. Veghte
James I. Clogston

A serious clothing problem is imposed on aircrew personnel because of space limitations in the cockpits of many jet aircraft. It is often difficult or impossible for flight crews to wear adequate clothing for protection in extremely cold environments that may be encountered during an emergency survival situation. The possibility of replacing certain garments of the standard AF winter flying assembly with newer and better insulated garments within the Air Force inventory was investigated as one approach to this problem. Such an assembly was devised and compared with the standard assembly by measuring various physiological responses of subjects in cold environments.

METHODS

The experimental program was conducted in two parts with the subjects either standing at rest or exercising continuously over the experimental period. Three different clothing assemblies were worn by each subject during the resting experiments while only two different clothing assemblies were worn by the exercising subjects. Therefore, each of the four subjects participated in five experiments.

The experiments were conducted at the Laboratory's field station on Paxson Lake, Alaska. Figure 1 shows the experimental environment. The experimental procedure consisted of taping the thermistors in place on the body (Figure 2), inserting the rectal probe 4 centimeters into the rectum, and donning a particular clothing assembly. The physiological measurements recorded during the experiment were rectal temperature and skin temperatures from 16 selected sites. During the exercising experiments the subject walked at a rate of 96 ft. per minute. This amount of exercise was considered to be light work. The physical variables monitored during the experiments were ambient temperature and wind velocity. A subject participated in only one experiment on any particular day. The duration of each experiment was 75 minutes. In an effort to assess and to compensate for the heat stored in the clothing prior to the experiment, the physiological factors were evaluated at the beginning of the experiment (-15 minutes) and again after the first 15 minutes of the cold exposure (0 minutes).

In Table II the average skin (Dubois) and rectal temperature response, mean body temperature (Burton), total body storage and the body storage rates, were calculated to determine the effective insulation of the clothing assemblies.

RESULTS AND DISCUSSION

The physiological responses of each subject to the physical conditions are tabulated in Table III. Figure 3 illustrates the average skin and rectal temperature responses to ambient temperatures for both the standing at rest and exercising subjects. The increment or decrement values for the skin and rectal temperatures are plotted to equate the various starting values. The skin temperatures began to respond almost immediately to the cold environment and did not reflect any thermal inertia due to an appreciable amount of heat stored within the clothing. Therefore, the initial physiological assessments (-15 minutes) appear to be valid over the range of environmental temperatures encountered during this experimental program.

The data from Figure 3 show clearly that there is very little difference in the rectal or skin temperatures while wearing any of the three clothing assemblies during the experimental period. It is interesting to note that the average skin temperature response for the three assemblies at rest appears to be independent of the clo values of the assembly for this particular time interval. This suggests a boundary layer of warm air, which if undisturbed will protect the person for at least a short period of time. The decrement values during exercise were less, considering all criterion measures--which is as expected with increased body heat production. The data were statistically analyzed, and no significant differences were found between clothing assemblies under conditions of standing at rest and exercising. It should be noted that Assembly C was not analyzed under the exercising condition.

Several measurements were taken after walking a prescribed distance wearing the three clothing assemblies. This exercise followed the standing at rest portion of the experiment described earlier. Average skin temperatures and rectal temperatures were lower for subjects wearing Assembly C. Subjective comments by the subjects indicated a greater degree of discomfort with Assembly C than with either Assemblies A or B. These additional data indicate that there is a greater amount of convective heat loss when wearing Assembly C than when wearing either Assemblies A or B. It is felt that once the boundary layer of air is destroyed by exercise the clo value of the assemblies become an important factor.

CONCLUSIONS

The experimental evidence clearly shows that clothing Assemblies A and B are comparable in effective insulation despite a difference in absolute weights. Clothing Assembly C is not considered as adequate as the other assemblies.

Recommendations

The new winter flying assembly (Assembly B) should be adopted for use by flying personnel within the Alaskan Air Command.

REFERENCES

1. Hall, J. F. and J. W. Potte. Thermal insulation of Air Force clothing. WADC, TR 56-482, Wright Air Development Division, Wright-Patterson AFB, Ohio. October, 1946.

TABLE I

Clothing Assemblies

Clothing Assemblies	clo Value **
1. Assembly A - Standard AF Heavy Flying Assembly:	
Shorts, 50-50 long underwear, A-1 shirt, E-1 and D-1 trousers, N-2A parka, 1 pair cushion sole socks, 2 pair heavy ski socks, 1 pair felt bootees, 2 pair felt insoles, mukluks, pile cap and experimental mitten with liner.	4.24*
2. Assembly B - New Assembly:	
Shorts, waffleweave underwear, insulated underwear (Type B), CWU-1/P, MA-1 jacket and hood, 1 pair cushion sole socks, 2 pair heavy wool ski socks, 1 pair felt bootees, 2 pair felt insoles and mukluks, pile cap and experimental gloves with liner.	4.10
3. Assembly C - New Assembly:	
Shorts, waffleweave underwear, CWU - 1/P, MA-1 jacket and hood, 1 pair cushion sole socks, 2 pair heavy wool ski socks, 1 pair felt bootees, 2 pair felt insoles, mukluks, A-1 mitten and liner. No pile cap. Experimental gloves with liner.	2.30

* All of these values are approximations based on similar assemblies tested on a copper mannequin.

** Hall and Potte, 1946.

NOTE: Assembly B weighs approximately 5 pounds less than Assembly A.

TABLE II

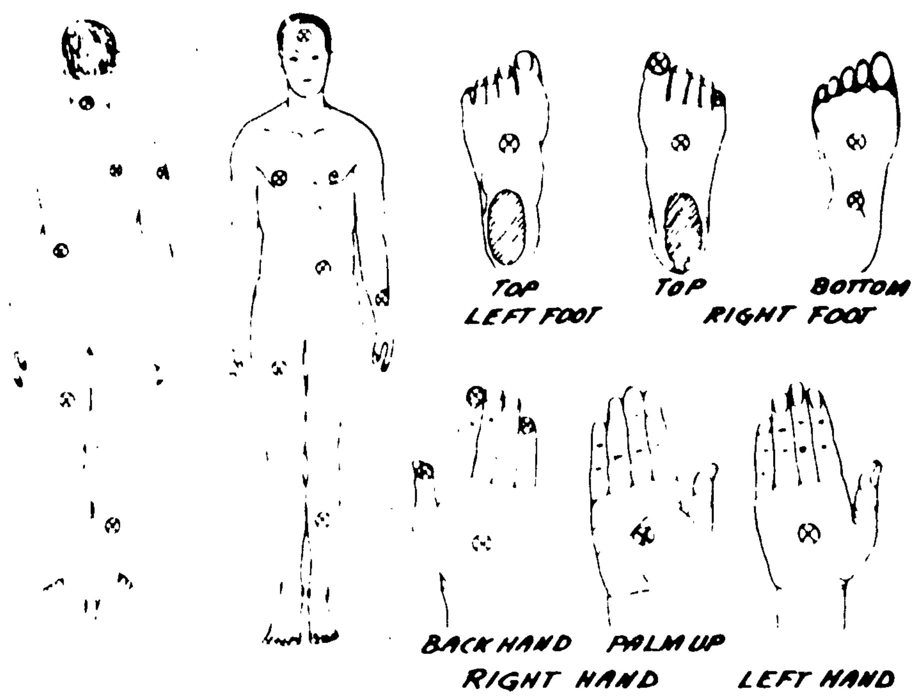
Subject's Characteristics

Subjects	Height (cm)	Weight (kg)	Age (yr)	Surface Area (m^2)	Occupation
A.	176	70.5	32	1.83	Lab personnel
B.	182	86.0	32	2.05	" "
C.	168	65.5	33	1.73	" "
D.	174	77.5	40	1.90	" "

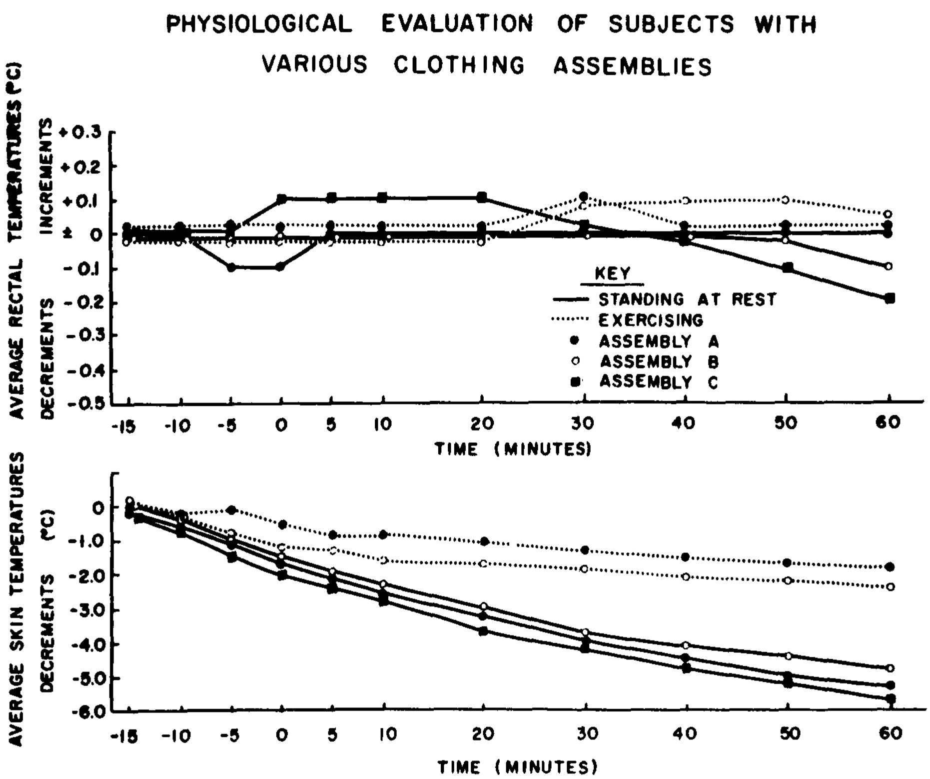
TABLE III

Physiological Responses to Experimental Conditions

Type of Experiment and Clothing Assembly	Subject	Average Ambient Temp(° C)	Avg. Wind Velocity (Ft/min)	RECTAL TEMP. Beginning (° C)	RECTAL TEMP. Terminal (° C)	SKIN TEMP. Beginning (° C)	SKIN TEMP. Terminal (° C)	MEAN BODY TEMP. (° C) Beginning Time(-15)	MEAN BODY TEMP. (° C) Beginning Time (0)	MEAN BODY TEMP. (° C) Terminal	BODY STORAGE DECREMENTS K cal / man Time(-15)	BODY STORAGE DECREMENTS K cal / man Time (0)	BODY STORAGE DECREMENTS K cal/m² hr Time(-15)	BODY STORAGE DECREMENTS K cal/m² hr Time (0)
Standing at Rest														
Test Series 1.	A	-30	69	37.1	37.0	33.9	28.2	35.9	35.2	34.0	-109.6	-69.2	-48.6	-38.4
Assembly A	B	-31	50	36.6	36.8	34.3	29.4	35.8	35.3	34.2	-114.2	-78.5	-44.6	-38.3
	C	-32	23	37.6	37.6	33.0	27.7	36.0	35.5	34.2	-92.4	-70.7	-42.8	-40.9
	D	-30	118	37.1	37.1	34.6	29.4	36.2	35.2	34.4	-51.5	-25.7	-21.7	-13.5
Average		-31	65	37.1	37.1	34.0	28.7	36.2	35.3	34.2	-91.9	-61.0	-39.4	-32.8
Test Series 2.	A	-30	139	37.1	37.1	33.3	28.5	35.9	35.2	34.3	-92.3	-57.7	-40.9	-32.0
Assembly B	B	-30	107	36.8	36.8	33.2	28.8	35.5	35.1	34.0	-107.1	-78.5	-41.8	-38.3
	C	-33	74	37.4	37.4	34.2	28.0	36.3	35.5	34.1	-108.7	-76.1	-50.3	-44.0
	D	-30	44	37.1	37.1	33.1	29.2	35.8	35.3	34.3	-90.1	-64.3	-37.9	-33.9
Average		-30	91	37.1	37.1	33.5	28.6	35.9	35.3	34.2	-99.5	-69.2	-42.7	-37.1
Test Series 3.	A	-34	0	37.0	36.7	32.2	27.0	35.3	34.7	33.3	-109.6	-80.8	-48.6	-44.8
Assembly C	B	-34	0	37.2	37.0	33.7	25.2	34.6	34.4	33.0	-76.1	-74.6	-35.2	-40.9
	C	-34	0	37.2	36.7	29.8	26.2	36.0	34.7	33.2	-192.7	-99.9	-75.2	-48.8
	D	-26	0	37.2	37.2	32.6	26.1	35.7	34.8	33.3	-148.0	-96.5	-62.3	-50.8
Average		-32	0	37.2	36.9	32.1	26.1	35.4	34.7	33.2	-131.6	-87.9	-55.3	-46.3
Exercising														
Test Series 4.	A	-31	1	37.1	37.3	32.7	32.5	35.6	35.4	35.7	+ 5.8	+17.3	+ 2.6	+ 9.6
Assembly A	B	-32	39	37.3	37.3	33.4	31.9	36.0	36.0	35.3	-50.0	-50.0	-19.5	-24.4
	C	-37	15	37.4	37.5	32.9	28.6	35.8	35.5	34.4	-76.2	-65.2	-35.2	-37.7
	D	-31	7	37.3	37.3	34.8	33.9	36.4	36.2	36.1	-25.7	-12.9	-10.8	-6.8
Average		-33	16	37.3	37.4	33.5	31.7	36.0	35.8	35.4	-36.5	-27.7	-15.8	-14.8
Test Series 5.	A	-36	18	37.1	37.2	32.5	30.7	35.4	34.9	34.9	-28.9	0	-12.8	0
Assembly B	B	-33	0	37.0	37.1	34.0	31.2	36.0	35.4	35.0	-64.2	-35.7	-25.1	-17.4
	C	-26	0	37.5	37.4	34.2	32.6	36.3	36.0	35.8	-27.2	-10.9	-12.6	-6.3
	D	-39	0	37.1	37.2	34.2	30.1	36.1	35.6	34.6	-83.6	-57.9	-35.2	-30.5
Average		-34	5	37.2	37.2	33.7	31.2	35.9	35.5	35.1	-50.9	-26.1	-21.4	-13.6


TOP
TOP
BOTTOM
LEFT FOOT
RIGHT FOOT
BACK HAND
PALM UP
RIGHT HAND
LEFT HAND

—FIGURE 2—


PHYSIOLOGICAL EVALUATION OF SUBJECTS WITH
VARIOUS CLOTHING ASSEMBLIES
AVERAGE RECTAL TEMPERATURES (°C)
INCREMENTS
DECREMENTS
+0.3
+0.2
+0.1
± 0
-0.1
-0.2
-0.3
-0.4
-0.5
KEY
STANDING AT REST
EXERCISING
ASSEMBLY A
ASSEMBLY B
ASSEMBLY C
-15 -10 -5 0 5 10 20 30 40 50 60
TIME (MINUTES)
AVERAGE SKIN TEMPERATURES (°C)
DECREMENTS
0
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
-15 -10 -5 0 5 10 20 30 40 50 60
TIME (MINUTES)

—FIGURE 3—